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Analysis of Earthquake Data from the Greater Los Angeles Basin and Adjacent Offshore Area, Southern California

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Element I & III

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ABSTRACT

We synthesize and interpret local earthquake data recorded by the Caltech/USGS Southern California Seismographic Network (SCSN/CISN) in southern California. The goal is to use the existing regional seismic network data to: (1) refine the regional tectonic framework; (2) investigate the nature and configuration of active surficial and concealed faults; (3) determine spatial and temporal characteristics of regional seismicity; (4) determine the 3D seismic properties of the crust; and (5) delineate potential seismic source zones. Because of the large volume of data and tectonic and geologic complexity of the area, this project is a multi-year effort and has been divided into several tasks.

RESULTS

Imaging of the Coso Geothermal Area Along the Intra-Continental Plate Boundary in Central-Eastern California: Regional Three-dimensional V_P and V_P/V_S Models and Spatial-Temporal Seismicity Patterns

We synthesize the tectonics of the southern Walker Lane belt and Coso Range in central eastern California using regional earthquake data. First, we invert for 3D models of the Vp and Vp/Vs structure of the upper and middle crust. Using these models, we also determine 3D Vs and Poisson's ratio models. The changes in seismic velocities across the region are small, except for low velocities in local sedimentary basins and a ~2 km positive elevation of the basement velocities (Vp > 6 km/s) beneath the southern Sierra Nevada. Localized low Vp and Vs zones beneath the central Coso Range image a geothermal reservoir at 0 to 3 km depth, as well as distinct velocity anomalies in the depth range of ~9 to ~12 km. Because the Vp/Vs has average crustal values within this broader zone, we interpret the anomaly to indicate a zone of 4-6% geothermal brines extending from 9 to 12 km depth. In addition, an embedded highly localized zone (possibly as small as 1 km^3) of slightly above-average Vp/Vs and higher Poisson's ratio is a tentative suggestion of a small volume-percent of magma present at depth of ~10 km. Second, we relocated the seismicity in the region using absolute traveltimes and differential traveltimes determined with waveform cross-correlation. The relocated seismicity forms several spatially clustered lineaments along the southeast side of the Sierra Nevada and in the Indian Wells Valley and vicinity of the Coso geothermal field, which coincide with mapped late Quaternary faults in the region. The base of seismicity shallows from a regional depth of about ~11 km to ~5 km beneath the central Coso Range, which we interpret as evidence for positive relief on the brittle-ductile transition zone beneath the geothermal field. The abundant Coso seismicity forms two major clusters, one within a radius of ~4 km centered on the geothermal field, and the second in the distance range of ~8 to ~12 km from Coso. The ~4 km radius zone of seismicity may be controlled by fluid injection or withdrawal from the geothermal area, while seismogenic deformation at ~8 to ~12 km distance may be associated with the crustal anomalies in the ~10 km depth range, as well as the regional transtensional deformation associated with the northwest motion of the Sierran microplate (Figure 1). (This is joint work with Dr. Unruh, and a manuscript is in press in JGR.)

Applying Bayesian Inference to Correlating Hypocenters and Southern California Community Fault Model (CFM): Quantifying Spatio-Temporal Evolution of Background Seismicity

We have applied the Bayesian inference approach of *Wesson et al*. (2003) to correlate hypocenters with individual fault segments of the Southern California Earthquake Center, community fault model (SCEC CFM 2.5). We analyzed a waveform relocated earthquake catalog from 1981 to 2005. We have included error estimates using the NonLinLoc method, which provides accurate Bayesian based error ellipsoids. The 3D distances from each hypocenter to the nearest 3D CFM fault segment were determined using GOCAD (Figure 2). We have also extended the method to include geologic slip-rates, as additional prior information for determining a probability for each hypocenter to occur on a CFM fault segment. In general, small faults have higher productivity of small earthquakes than large faults. The San Jacinto fault has the largest association probabilities because of high rate of background seismicity and high slip-rate. In contrast, the San Andreas fault system has smaller association probabilities. This is caused by a lower rate of microseismicity along the San Andreas, and the background seismicity appears to be more distant from the fault trace. The b-values associated with individual fault segments, often decrease toward the fault implying that the large earthquakes are more likely to occur on the mapped faults, with a higher association probability than the smaller ones. These results suggest that as faults evolve and accumulate a significant amount of slip, the rate of associated background seismicity evolves from being high and focused on the primary fault trace, where large earthquakes occur, to a lower rate that is more diffuse and spread over a broader region. (A manuscript describing this work is in preparation for BSSA).

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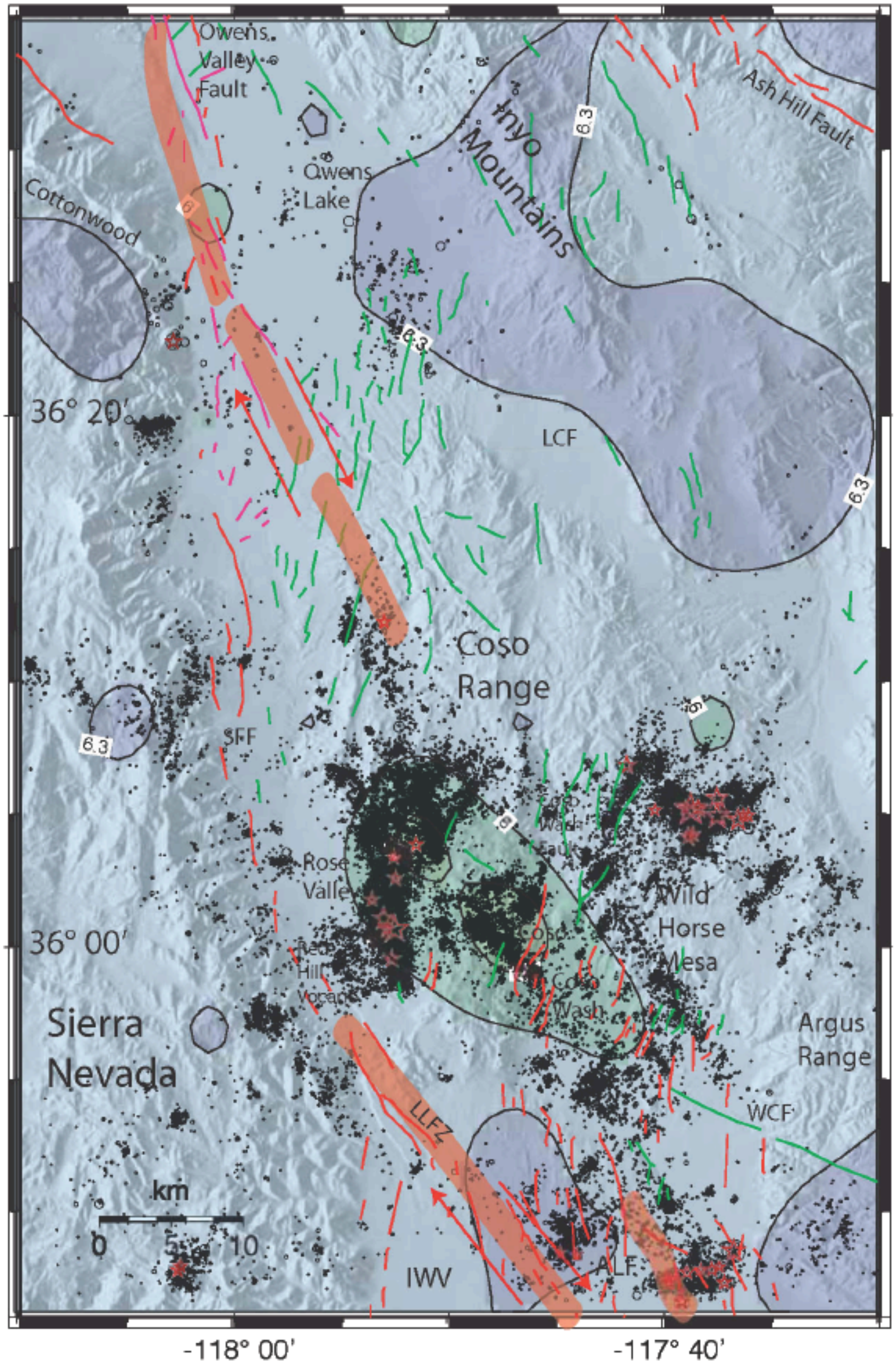

Figure 1. Schematic view of transtensional tectonics of the Coso region. Extensional faulting within the Coso Range occurs in a releasing right stepover between the Owens Lake fault to the north and the Airport Lake fault to the south. The low Vp anomaly beneath the central Coso Range coincides with the releasing step and locus of transtensional crustal thinning. Superimposed on the background topography is the 3D Vp model at 10 km depth, relocated seismicity and mapped faults; red- Holocene; green – late Quaternary. IWV- Indian Wells Valley; LLFZ – Little Lake Fault Zone; SFF – Sierran Frontal fault; WCF – Wilson Canyon fault; LCF – Lower Centennial Flats; ALF- Airport Lake fault.

Distance to faults

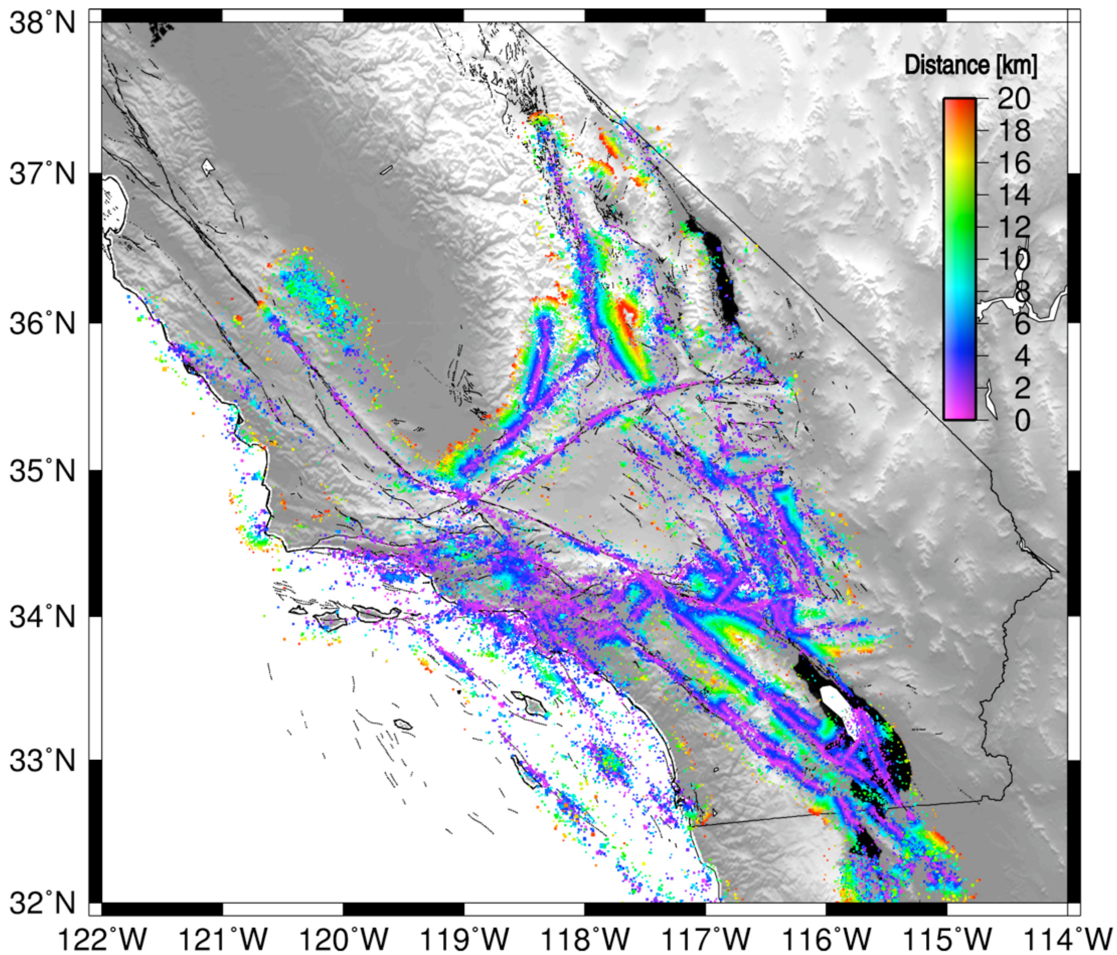

Figure 2. 3D distances from ~380,000 hypocenters to 165 faults in the SCEC community fault model. Distance is color coded with purple being closest to the fault.